THREE-DIMENSIONAL ADJUSTMENT OF STRATIFIED FLOW OVER A SLOPING BOTTOM

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LONG-TERM GOALS

Our ultimate goal is to understand the dynamics of strong, narrow ocean currents that persist for hundreds or thousands of kilometers, despite being in contact with the (frictional) bottom.

SCIENTIFIC OBJECTIVES

Our immediate objective is to understand how vertical mixing and advection within the bottom boundary layer influence the three-dimensional structure, evolution, and dynamics of both the bottom boundary layer and the overlying (interior) flow.

APPROACH

Our study is based on our idealized semi-analytical model of the adjustment of a stratified flow over a sloping bottom (Chapman and Lentz, 1997) which suggests that an equilibrium can be achieved in which both the bottom boundary layer and the overlying current adjust through feedback mechanisms such that the bottom stress is reduced to zero everywhere. The current can then continue unimpeded by bottom friction. Our approach consists of three parts: (1) we are using a primitive equation numerical model to elucidate and extend results from our idealized model and to determine the limitations of our idealized model; (2) we are analyzing existing observations to determine whether the structure of the bottom boundary layer and the flow field above are consistent with our idealized model; and (3) we are attempting to extend the idealized model to more realistic conditions.

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WORK COMPLETED

This being the first year of the study, we have only begun the first two parts of the work. We have configured the numerical model (SPEM5.1) to reproduce, as closely as possible, the idealized model. This provides a test of the robustness of the idealized model because the numerical model includes nonlinear advection of momentum, vertical structure in the bottom boundary layer, full cross-isobath advection of density, and a parameterization of vertical mixing, all of which were either neglected or highly simplified in the idealized model. Furthermore, the numerical model requires a finite domain with open boundaries, both of which complicate the comparison.

We have identified and acquired several data sets that seem appropriate for comparison with the idealized model. These include: long-term shelf observations from the west coast of the U.S., slope observations of the California Undercurrent, Nantucket Shoals Flux Experiment moored observations from the Middle Atlantic Bight shelf and moored observations from the Deep Western Boundary current acquired by Wunsch and Hendry in 1970.

RESULTS

For a weak narrow inflow, the numerical model solutions behave very much like the idealized model in many respects. The growth of the bottom boundary layer and the adjustment of the overlying flow are both qualitatively and quantitatively similar to the idealized model. A downstream equilibrium is achieved, although only after a very long simulation time. The adjustment near the inflow is quite different from the idealized model (as expected) owing to the presence of nonlinear momentum advection. The impact of the open boundaries still needs to be reduced before further comparisons can be made. Also, very strong and narrow inflows appear to behave differently from the weaker inflows, although this conclusion is quite preliminary.

Examination of monthly mean current profiles from the STRESS/SMILE (Sediment Transport Events on Shelves and Slopes; Shelf MIxed Layer Experiment) studies on the west coast of the U.S. (in collaboration with John Trowbridge) indicate a shutdown of the bottom stress consistent with our idealized model. However, consideration of the alongshelf momentum balance also suggests there is an alongshelf density gradient which is not consistent with our idealized model, but may be a consequence of the complex bathymetry.

IMPACT/APPLICATIONS

We expect that our results will show the important (and perhaps dominant) influence of the bottom boundary layer on ocean currents, even when the boundary layer is thin compared to the current depth. This may alter the way in which currents are observed and modeled in large-scale models.

TRANSITIONS

There are no transitions at this point.

RELATED PROJECTS

None

REFERENCES

Chapman, D. C., and S. J. Lentz, 1997. Adjustment of stratified flow over a sloping bottom. *J. Phys. Oceanogr.*, **27**, 340-356.